A MECHANICAL MODEL FOR HIP REDUCTION VIA PAVLIK HARNESS IN NEWBORNS

Josean Ruiz, Janina Helwig, Gabriela Espinoza, Kristin Sverrisdottir, Shanice Jones

Embry-Riddle Aeronautical University, Daytona Beach, FL

https://sites.google.com/site/eraumebmssd1516hipdysplasiaexp/

INTRODUCTION

- Developmental dysplasia of the hip (DDH) is an abnormal condition in infants and commonly treated by the use of the Pavlik harness.
- 1 out of every 20 babies has some hip instability.
- The effectiveness of the Harness depends on physician expertise, experience and trial-and error procedures.
- For a better understanding which procedure with the Pavlik harness is most effective a multi-physics computational approach has been done.
- To prove the results of the computational approach a mechanical model is needed which will provide physicians a better understanding of the mechanics of DDH when using the Pavlik Harness.

Figure 1. ***Infant wearing a Pavlik Harness***

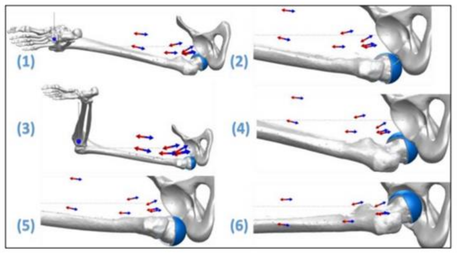

Figure 2. This computational model with grade IV dislocation and its path of reduction has to be proven with a mechanical model

- Replicate an infant's hip with DDH and the 7 muscles important during the hip reduction.
- The mechanical model will be scaled proportionally to the size of an infant and simulate the passive muscle forces.

METHOD

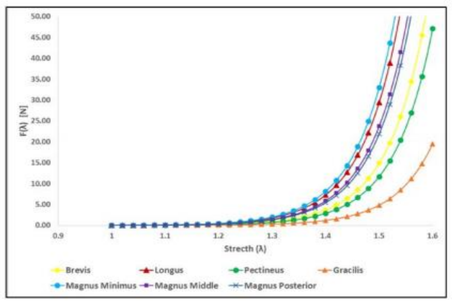

Figure 3. Each muscle has an individual force vs. stretch curve representing the passive muscle force; these curves have to be replicated

- Trial and error experiments will calibrate the pneumatic to adjust for the right pressure that will replicate the individual curve
- The data of the path of reduction of the femoral head will be acquired by IMUs, and will be processed using MATLAB.

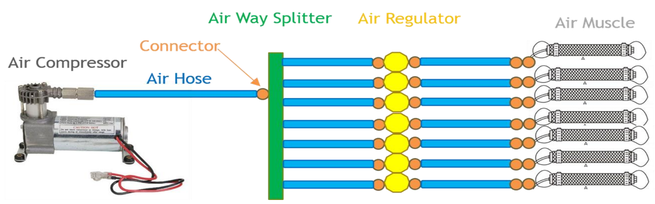

Figure 4. Set up of the 7 pneumatic muscles attached to an air compressor

ABSTRACT

Developmental Dysplasia of the Hip (DDH) refers to an abnormal hip condition in neonates characterized by anomalous development of the hip joint, in which hip joint dislocation, misalignment, and musculoskeletal instability are present in newborn infants.

Clinical reports and previous research indicate very low success rates for the Pavlik Harness for severe grades of hip dislocation; statistically, it has been shown that for reduction rate for the International Hip Dysplasia Institute (IHDI) Grades I-III is 92% while only 2% for grade IV.

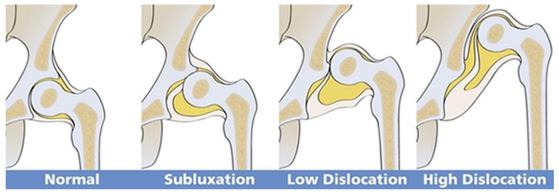

Figure 5. From Left to Right IHDI Grades I-IV

In order to experimentally verify the computational model of the hip reduction and abduction via the use of the Pavlik Harness in severe cases of DDH, a mechanical bench-top model is to be designed, built and tested for the four grades of dislocation.

This approach will be repeated for three patient-specific neonate musculoskeletal models, as to corroborate the use of this experimental bench-top design in the validation of the patient-specific computational model.

The primary impact of this project on society will be to assist in the improvement to the success rate on non-surgical interventions for patients with DDH, as well as its consequences in adulthood; DDH is found responsible for 29% of primary hip replacements in people up to 60 years of age.

BUDGET

Figure 6. The 3D printer MakerBot 5th Generation has been the most expensive purchase

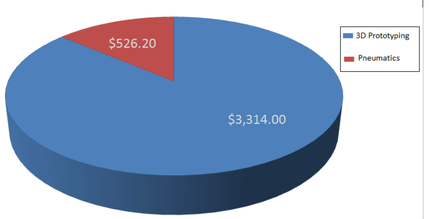

Figure 7. Visual representation of budget divided between 3D prototyping and Air muscle pneumatics; Total Budget is $3840.20

RESULTS

- A scale of 4x for the model was calculated to be practical for teaching purposes

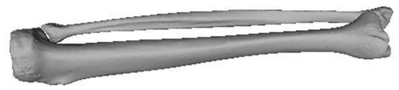

Figure 8. The lower extremities were created using a CAD software, ready to be 3D printed

Figure 9. McKibben air muscles have been chosen to replicate the individual force vs. stretch curves; by varying the pressure the passive muscle force can be adjusted

Figure 10. Foot and tibia have been printed with a scaling factor of 4

- The team successfully created a 3-D printed model of the right half of the lower extremities that will be used to visualize the desired points of origin and insertion.
- The 3D model will also help to visually understand what is happening during the hip reduction process in order to implement this procedure on a patient-specific case.

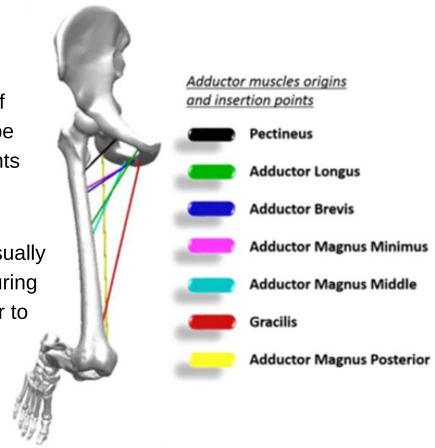

Figure 11. Right half of the lower extremity with muscle location

REFERENCES

Huayamave, Victor A. "Biomechanics of Developmental Dysplasia of the Hip - an Engineering Study of Closed Reduction Utilizing the Pavlik Harness for a Range of Subtle to Severe Dislocations in Infants." Diss. College of Engineering and Computer Science at the Univeristy of Central Florida, 2015. Print.

ACKNOWLEDGMENTS

Dr. Eduardo Divo , Associate Professor of Mechanical Engineering at ERAU

Dr. Victor Huayamave, Assistant Professor of Mechanical Engineering at ERAU

Dr. Charles T. Price, Professor of Orthopedic Surgery at UCF-School of Medicine